COMPARISON OF SPECTROPHOTOMETRIC EVALUATION OF SHADE SELECTION WITH VISUAL AND DIGITAL METHOD

Dissertation submitted to

The Tamil Nadu Dr. M.G.R. Medical University

in partial fulfillment of the requirements for the degree of

MASTER OF DENTAL SURGERY

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INCLUDING CROWN AND BRIDGE AND IMPLANTOLOGY

MAY 2019

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S.PREETHI SUGANYA

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including crown and bridge and implantology

Under the guidance of
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2016-2019

Tamil Nadu Dr.M.G.R. Medical University

MAY 2019

DECLARATION

I hereby declare

that this dissertation entitled

COMPARISON OF SPECTROPHOTOMETRIC EVALUATION OF SHADE SELECTION WITH VISUAL AND DIGITAL METHOD

is a bonafide and genuine research work carried out by me under the guidance of

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by the Head of the Department and Principal

This is to certify that the dissertation entitled

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CERTIFICATE - I

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CERTIFICATE - II

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ALL FAME TO ALMIGHTY

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A smile could convey a thousand different meanings, yet it is the most easily recognized expression. A charming smile can change drowning things and can give positive aura. But every person is not blessed to have a attractive smile. The answer to the above problem is esthetic dentistry which has developed leaps and bounds with the latest technologies and materials.

Esthetic dentistry is defined as an art and science of dentistry, applied to create or enhance the beauty of an individual within functional and physiological limits. Esthetic dental treatment aims to achieve a patient's own intensity, personal image of how he or she looks like and how he or she would like to look. A strong wish to look beautiful is no longer taken as a sign of pride. In an economically competitive world, a pleasing appearance is a prerequisite and implies the difference between success and failure in both our personal and professional lives. Esthetic dentistry primarily focuses on improvement in dental esthetics such as color, position, shape, size, alignment of teeth and overall smile appearance.

Increased patient awareness has led to an increase in demand for esthetics. Improper shade selection is said to be the second factor for remake of ceramic restorations, primary reason being the problem with the tooth preparation and impression making. Being a dentist, restorations done on a maxillary anterior tooth region and also fulfilling the desires of a patient, is like walking on the double edge sword. Hence to overcome the problem, proper understanding and knowledge of color is important.

Color is best described as an abstract science and color appeals to deal with both visceral as well as emotional senses. Color is personal and each individual will view the same object differently. The basic knowledge of how the color will be perceived and reproduced will aid the clinician in evaluating and matching the shades in dentistry. Since dentistry is a demanding profession. There are many challenges that can and will appear. This is especially true with cosmetic work. Hence certain systemic guidelines in place, can make this part of esthetic dentistry rewarding for both dentist and the patient.

In dentistry, Prosthodontist is probably the best person to identify the quality of smile. Further he is able to change the quality of treatment with the recently available innovative techniques and to plan restorations.

Hence in prosthodontics, shade selection is an important procedure to provide patients with an esthetic restoration that harmoniously blends to the patient's existing dentition. Due to the greater variety of tooth color, achieving a close shade match of an artificial restoration with the natural dentition is a complex process. Practitioners require an understanding of color, light and related characteristics of porcelain and resin as well as the ability to clearly communicate instructions with the lab technician inorder to obtain natural looking restoration.So the main aim of the study was to find out the possible shade differences between the human eye and digital method using spectrophotometry.

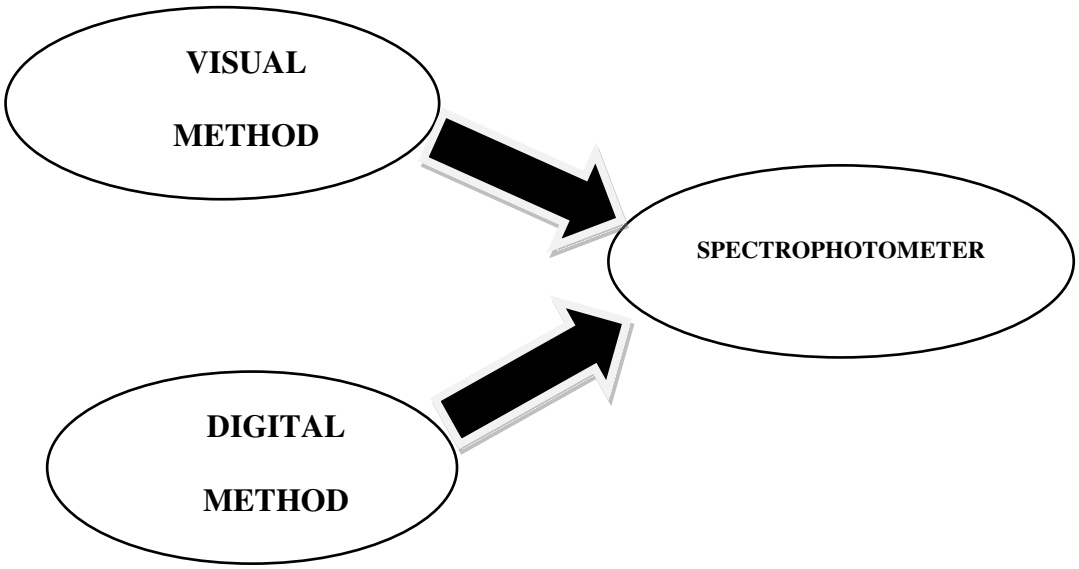
The specific conditions that initiate a need for esthetic treatment includes discoloration due to extrinsic and intrinsic staining, anomalies due to developmental disturbances, abnormal spacing between teeth and trauma.

There are two steps in shade selection:

1. Selection of color and

2. Consequently the mode of communicating the shade to the laboratory

The aim of the study was to compare the shade selection using two different methods namely, Visual method (VITA CLASSICAL) and Digital photography method (CANON EOS 750D) with Spectrophotometer (VITA EASY SHADE COMPACT)



Dean Farnsworth (1943) discussed the Farnsworth –Munsell 100 –Hue and Dichotomous test for color vision. It has been described for the evaluation of color anomaly. The importance of undergoing color test for the investigator were gleaned from the literature. So its necessary for the investigator to undergo Munsell and Dichotomous test in order to find out peculiarity.

G.Verries (1963) conducted study on color discrimination based on age and sex. From this literature it states that pseudo isochromatic principles are not quick to respond and do not identify reliable differences. Inspite, the acquired deficiencies of color discrimination are not often well delineated as the congenital ones. This article describes the occurrence of different type of ocular deficiency.

William D. Culpepper (1970) conducted comparative study on shade matching procedures. He conducted shade selection using four different shade guides under four different light sources. The selection of shade vary among the observes and he concluded the study by saying that practising dentist can select the shade according to surrounding lightening conditions and to his own fulfilments and to that of his patients.

J.Mellerio (1970) did a study on light absorption and loss in human lens. As increasing ageing, lenses of human grows bigger and yellower. The light transmission of human lens is deliberated at five predictable wavelengths. The loss is directly proportional to concentration of pigment. It remains uniform throughout intermediate of the lens about 7-8mm and constant between the ages 20 and 60.

Stanley Coren (1971) conducted an in vivo study on older age groups based on solidity of human lens pigmentation. It states that incase two metameric colors appear similar and if web ring color filter infront of them they will no longer materialize same. In order to quantify the density of pigmented lens, one must appoint the spectral transmission. The obtained points can be used to decide the density of pigment.

Stephen F. Bergen (1977) put forward how important to select the shade discrimination in dental clinic with variable lightening conditions. All colors will be revealed as the patient desires, if the spectrum of light contains all desired colors. Hence setting upon the dental clinic with proper lightening source is important for distinct shade matching. This study states that less weariness of eye is produced by full-spectrum bulb compared to a cool white.

Edwin H. Land (1977) discussed how the visual system is able to withdraw the color information from the surrounding atmosphere and how eye makes remarkable attention from the world to make interesting fact about retinx theory of color vision. This article describes about how the rods and cone cells of retina illuminates light and works as color vision in human beings.

Rolf G. Kuehni(1979) carried out an experiment on visual scaling of small color differences involving six color microspaces. Subjective estimation, allowed judgements, and ranking are used to estimate the color samples. Traditional methods are used to calculate the visual scales. Mutual relations were premeditated between color difference formulas such as CIELAB, IELUV, FMC-2 , FCM and with visual scales.

Charles G. Saleski (1972)formulated a standardized lightening for prosthetic reproduction in shade selection between dentist and in dental laboratory. Color is the most important thing to be taken into an account and the knowledge and tools to color do survive. By making use of an available technology for functional prosthesis, dentist can establish the same technical excellence for esthetic purposes.

Gerard J. Barna(1981) did an in vitro study on color perception within the color range of natural teeth. He said that object variables, observer variables and light source variables are effected by colors. By reducing the variables in the object and the light sources, normal variables of the observer can be controlled. It is evident that practising alone could not increase the skill and it requires proper training for color discrimination.

Lynda K.Bangtson (1982) conducted an experimental study for the conversion of Chromascan designations to CIE trisimilus values. In restorative and prosthetic dentistry matching the shade remains dare. Color selection becomes convoluted by individual differences in color identification skills and color perception.

R.R Seghi (1986)this study was aimed to use instrumental colorimetric techniques to estimate the color changes between the porcelain systems. The dental profession is facing many plights in matching porcelain systems with natural human dentition. The difficulty of product variations with respect to production of color is well understood clearly by ceramist but has not been quantified.

W.M. Johnston (1988)this study compared the color match by visual method and instrumentation such as clinical colorimetry. Some plights arise whether problems evident by visual or instrumental method. Individual observer may record vary colors from time to time and leads to color mismatch. United States Public Health Service (USPHC) has implemented several criteria for visual observer. Instrumental colorimeter provides similar parameters of different objects when any colorimeter is given.

T.P. Van de Burgt (1990) compared shade by using three different methods namely visual, fibre-optic colorimeter and spectrophotometer. The measurement should be copied, realistic and balanced and easy to use. Entire calibrations should be recorded intra orally and not involving any damage. This research ends up with results that fibre-optics colorimeter is a promising instrument with some theoretical or scientific improvement is necessary.

S.P.Davison (1990) explored and investigated four type of innovate groups. They were1) color defective dental students and dentists 2) assistant with normal color vision 3) prosthodontist with normal color vision 4) control group. This study concluded that color defective dental students decreased the ability to match accurate shade selection. Assistant with normal color vision shows statistically significant results.

James L. Donahue (1991) discussed about color evaluation among men and women. Twelve students (6 men and 6 women)were selected between 24 to 35 years of age. Both should undergo color blindness test. Three different shade guides (VitaLumin

vacuum, Crystal porcelain, bioform) and three different lightening sources (North daylight, Lumin shade light, fluorescent) were used. Women agreed more with Vita Lumin compared with Crystal porcelain and bioform.

Rene A Bolt (1994)conducted a study on extracted incisor teeth fixated with formalin. The tooth color is normally measured with a small window by the illumination passing through it. When light gets entered into small window for color discrimination, an edge loss error occurs. In order to overcome such errors external diaphragm was provided with spectrophotometer using spectroradiometer and detector.

M.A. Crognale (1997)conducted a study on extremity of color shortcomings by using electroretinographic (ERG) and behavioural studies. The aim of the study was to calculate the existence and separation of photo pigments in human observers and how far electroretinograph concludes to improve the color matching from molecular analysis. This investigation helps to find out normal and color defect persons.

Scott R. Okubo (1998)discussed the shade matching of ceramic shade guide (VitaLuminshade) by using conventional and instrumental shade matching using computerized colorimeter such as Colortron II . Colotron correctly matches 8 tabs from 16 whereas visual matches 7.7 out of 16. Hence states that Colotron II is slightly better as it matches 50% correct tabs when compared to visual, it matches 48% correct tabs.

Carolyn Bentley (1999) conducted a study on Night guard Vital Bleaching (NGVB) by digitalized means. The shade tab and clinical cases were photographed by using camera on35 millimetre film with focal length of 100mm f/4 lens and automated flash. The image was then digitalized in the computer and stored as red, green and blue (RGB) format. Photoshop was done with commercially available software.

Akira Hasegawa (2000) did an in vivo study for color and translucency on natural central incisor of 42 men and 45 women of different age groups using spectroradiometer color computer model PR -650 Spectra Colorimeter instrument with Macro-Spectra MS-75 and SL-1X lens. This articles reaches to clarify translucency and color difference for five sites namely cervical, center-cervical, center, incisal-center and incisal between the natural teeth and VITA Lumin Vacuum shade guide. It concluded that natural teeth showed decrease in lightness from center to the cervical site and drastically increase in yellow color at all five site with progressing age. Vita Lumin shade provide less lightness as compared to that of natural teeth.

Stephan Phelan (2002) discussed the importance of team work for shade matching in dentistry. Historically it states that communication between dentist and lab technician via dental prescriptions like hue, value, chroma, hypocalcification and pit and fissure characterization. It sounds quite difficult for the technician as he cannot see the patient and communication could be one way as telling by the dentist as what he required. In order to overcome this situation, communication via photograph is invented.

S.Paul (2002) did an in vivo study on accuracy of color matching in dentistry. 30 patients were selected (14 male and 16 female) with different age groups ranging from17- 44 years. Three dentists used to find out the possible shade based upon conventional method using Vitapan Classical shade guide. Intra oral camera is used to measure shade by spectrophotometric methods. This study shows spectrophotometric analysis is more accurate compared to conventional shade selection.

Wolfgang M. Bengel (2003) discussed about the images taken by digital photography that eliminates color cast by neutral reference such as grey reflectant card and also provides better therapeutic results after bleaching procedures. This article describes about the factors that affect color performance and brightness in photography. However digital photography could results in rendering the cause for brightness in images.

Lambert J.Stumpel III (2004) discussed the easy way of rectifying digital images in shade communication with dentist and the dental technician in laboratory. After taking the pictures, image gets analysed using the computer software (Adobe CS, Adobe Inc, San Jose, Calif) and processed with the toolbars present in the software. Finally save the image and send to the lab technician for further process.

Alma Dozic (2004) did an in vivo study on dental students and ACTA employees with some of the inclusion criteria's of 1min brushing with soft tooth brushes and classic tooth paste and exclusive criteria of fractured teeth, caries lesions. The purpose of the study was to find out possible color relation between L*a*b* values of incisal, middle and cervical segments of vital teeth by capturing images using digital camera

with proper camera settings. There was a statistically significant co relation found between L* and b* values when compared to L* and a* values because intermediate coefficient of L* and a* is relatively low.

H.Dagg (2004) explained clearly about some circumstances on which accuracy of shade replication depends. Custom shade tabs were fabricated from Vita and Shouf porcelains. Four main considerations were, contrast between two porcelain system, outcome of thickness of porcelain, result of light quality and the more involvement or experience of observer. The results showed more influence for the shade selection is light quality

Jane D. Brewer (2004) emphasised about recent development in color matching system. Older conventional method shows lot of color differences in shade matching due to external influences like age, disease and drug therapy. Over last 20 years, a number of laboratory and clinical findings of instrumental measurement been published. This articles briefly explains about visual shade matching and instrumental shade matching such as colorimeter (Shade Eye, Shade Scan), digital imaging (Clear Match, Spectro Shade) ,spectrophotometer (Easy Shade) and spectroradiometer.

Mostafa Analoui (2004) did an in vitro study on 150 extracted human teeth. Vita Lumin V, TrubyteBioform Color, Vitapan 3D-Master are the commercially available shade guide employed in this study. The L*a*b* values of shade guide were measured by using spectrophotometer. Visually optimal shade guide provides less error.

Burkard Hugo (2005) did an in vivo study on shade matching based upon visual and computer aided shade matching. It is important for day to day practitioner whether computer shade matching will be accurately useful in everyday life. The Spectro Shade device (MHTOptic Research AG,8155 Niederhasli, Switzerland), the Shade Vision device (X –Rite Co.,) and Digital Shade Guide DSG4 (A. Rieth, Germany) are based upon computer- aided determination.

Shigemi Ishikawa –Nagai (2005) discussed the precise of replication of color scale or spectrum for ceramic restoration using CCM (Computer Color Matching) employing a prototype program and spectrophotometric data's. To implement CCM technique of ceramic restoration, the entanglement of tooth color gradient should be taken into an account. Color reproduction takes place from incisal through the cervical regions.

Jarad FD (2005) discussed about color determination by observation and computer matching method. Shade matching has always been tedious job in dentistry and satisfying the patient is quiet difficult. This article describes two methods namely Vita Lumin shade guides (A2,A3,A3.5,B2,B3,B4,C1,C2,C3) and digital camera (Nikon Coolpix 990) and colour values obtained by digital camera is verified by using spectrophotometer.

Alvin G.Wee (2006) discussed about the perfect colour matching using digital camera in dentistry. Images were taken digitally by the following single lens reflection (SLR) cameras such as Nikon D100 with charge couple device (CCD), Canon EOS D60 with CMOS (complimentary metal oxide semi-micro conductor sensor and Sigma

SD9 with Foveon × 3 CMOS sensor. This study shows that SLR camera with appropriate settings and protocols helps in accurate reproduction of color.

Seungyee Kim-Pusateri (2007) did an in vitro study for the accuracy and reliability of tooth color. This article compared three commercially available shade guide such as VITA Classical (VITAZahnfabrik), VITA 3D Master (VITA Zahnfabrik) and Chromascope (IvoclarVivadent) with shade matching device such as Shade Scan (Cynovad). The results shows that reliability of tooth color for VITA Classical will be more followed by VITA 3D Master and Chromascope and accuracy of tooth color for VITA Classical will be more followed by Chromascope and VITA 3D Master.

R. Khurana (2007)discussed a shade matching procedure under the clinical conditions with a well skilled operator. The procedure was done in natural daylight using three commercially available devices such as Vita Easy Shade Spectrophotometer, Spectro Shade Micro and X-Rite Shade Vision Colorimeter. The most important aspects in color dentistry is color judgement and replication of color in restoration.

Monica Anand (2007)did a shade matching using instrumental methods and computers. Instrumental methods of color section could be preferred over visual methods since it is unbiased and speedy. This process eliminates the speculation or guesswork of shade as it is more accurate and intend to produce esthetic benefits of the patient, dentist and the dental technician. Recently it includes computerized shade selection method in the market.

Alma Dozic (2007) conducted both an in vitro and an in vivo study on accuracy and precision of shade matching in five commercially available devices. Five shade tab such as A1, A2,A3,A3.5 or A4 of the Vita Lumin shade guide placed in phantom jaw to determine color matching by using five available device such as Shade Scan, Ikam, IdentaColor II, Shade Eye, Easyshade was done. For in vivo study 25 dental students selected without any restoration on maxillary anterior with informed consent.

Q.LI and Y.N. Wang (2007) discussed shade determination among visual and colorimeter. Twenty people (11 women and 9 men) were selected between the age groups of 19-32 years. Two prosthodontist and one dental technician were employed in this study for visual assessment of shade using Vita Lumin shade guide. ShadeEye NCC is the intra oral dental colorimeter used in this study. This study concludes that ShadeEye NCC provides better results when compared to visual assessment.

Alvaro Della Bona (2008) conducted a study with three group of populations such as general population (non dentist or GP) and first year dental students (DS) and with an experienced dentist (DD). Shade tab was observed by general population and natural central incisor was observed by DS and DD under two lightening conditions such as in natural day light and in cool white fluorescent. Intra-oral spectrophotometer helps to identify natural central incisor and shade tab

John D. Da Silva (2008) conducted an in vivo study on 36 subjects using two different shade matching techniques such as conventional and spectrophotometric methods. Vitapan Classical, Vitapan 3D-Master and Chromascope are the three guide

system used in this study. Metal ceramic crown was prepared by using both conventional and spectrophotometric methods for best color reproduction.

Jin –SooAhn(2008) did a study on shade tab (Vitapan 3D Master) for hue, value and chroma scale by using spectrophotometer. Before undergoing shade determination procedure, the middle portion of the shade tab were polished with silicon carbide paper. By making flat on the middle surface, the measurement becomes more accurate when compared to cervical and incisal regions.

SS Meireles (2008) did a study for the affirmation and reliability of conventional evaluation with shade guide. 92 individuals (18-55 years of age) were selected for the study. Two well trained dentist participated for visual shade selection. They underwent two phases of training like knowing complete knowledge of color, factors influencing color and method of shade selection.

David Gozalo- Diaz (2008) conducted an in vivo study about color matching on maxillary central incisor among 120 humans based on age and gender. Age groups vary as follows 18-29 years, 30-39 years, 40-49 years, 50-59 years and 60 – 85 years among four racial groups (White, Black, Pacific Islander, Asian). Color of the object is measured by spectroradiometer and with the help of an external light source

T. Roma Jasinevicius (2009) did a study in color determination among the dental technician such as twenty male and twenty female under light conditions in the individual laboratory. The main purpose of the study was to find out any possible difference exist between age (18-61), gender and light sources (shade matching quiz

lab) and dental experience of 1-44Years. Not containing any logical contradictions with other studies it proved that there was no difference evident on experience or gender.

RadeD.Paravina (2009) conducted an in vivo study on shade matching with dental students after getting approval from the ethical committee. Four Targets shade tabs (target tab 1-1M1.5; target tab II -2R2.5; target tab III –A3 ; target tab 1V-4.5M2)were selected and compared with four dental shade guides (3D Master, Vitapan Classical, Prototype of Linearguide 3D-Master , Final version of Linearguide 3D-Master)

Lars Schropp (2009) discussed about visual and digital evaluation of shade selection. Vita 3D-Master guide was selected since it is used mostly in clinic scenario. Twelve tabs were selected and placed in phantom head and observation was done by nine observers. Similarly digital photography was taken under clinical environment with camera settings and color matching was done by computer software. It concluded that digital photography gives better results when compared to visual method.

Seungyee Kim-Pusateri (2009)discussed about precision and reliability of four shade matching devices. Three commercial shade guides such as Vitapan Classical, Vitapan 3D-Master and Chromascop were used in this study. Using ultrasonic cleaning solution, the shade tabs are cleaned before shade matching. For reliability test, one tab selected from each shade guide and compared 10 non-consecutive times with four shade matching devices (SpectroShade, ShadeVision, Vita Easyshade,

ShadeScan) and for accuracy 10 shade tabs from each shade guide selected and measured once with shade matching devices.

Burak Yilmaz (2010) did an in vitro study on color reproduction of metal ceramic specimens by using conventional methods and intra oral colorimeter. Five different shade tabs (A1,B1,C3,D3,A3.5) were used from Vitapan Classical shade guide. For instrumental method, ShadeEye NCC is used. Results were displayed as color reproduction of visual matching is more reliable and precise when compared to instrumental method.

Stephan J. Chu (2010) discussed about advancement and eagerness of color reproduction that gradually influenced modern dentistry. This article gave an idea about current trends of handling color matching in clinical practise. In those days when keywords are given in Medline search only limited articles could give reference but now it increased to 409 papers as well. For easy communication, esthetic purpose, color reproduction both visual and instrumental shade matching is important

Won- suk Oh (2010)conducted a study on visual and digital photographic method. Vitapan Classical shade guide is employed in the study. Although it was performed with certain standard conditions, it is quit difficult for the lab technicians as he cannot see the patient. Spectrophotometer is a reliable method but cannot be used since it is not cost effective. Digital matching of tooth selection helps in transferring image to the laboratory and makes more effective in color reproduction.

Yong-Keun Lee (2011)discussed about perceived shift in color under different lightening conditions. Based upon measurements given by spectroradiometer, Vitapan 3D-Master shows a considerable amount of change in color under three illuminants. CIE standard illuminantD65 (daylight), F9 (fluorescent lamp) and A (incandescent lamp) are the different illuminant used in the study.

Elizabeth Sarkis (2012) did an in vitro study for color changes of five dental materials. Disc shaped sample was prepared and light cured with Plasma arc composite. One side was polished with Super-Snap system and remaining side left unfinished. Digital spectrophotometer used to measure color after 24 hours. Unfinished surfaces shows more coloration when compared to finished surfaces.

Deger Ongul (2012) did an in vivo study for color matching in dentistry. Thirty three subjects were selected and ceramic crowns were fabricated on maxillary central incisor by using two shade guide system such as Vitapan Classical and Vita Tooth guide 3D-Master.Spectrophotometer helps to calculate the color values of these shade guide system. The results shows that crown fabricated by Vita 3D-Master shows closer values of natural tooth.

Shobha Rodrigues (2012) conducted an in vivo study on shade difference between natural anterior teeth among different age groups and gender using 3 shade guides namely Vita Lumin, Vita 3D-Master and Chromascop. The results shows no statistically significant result in both sexes and in different age groups. However as the age advances, there is a significant darkening of the teeth.

W.K Tam (2012)did an in vitro study on shade matching between conventional and digital method. Vita 3D-Master and Canon EOS 1100D were employed in the study. The shade guide was captured by digital camera at a distance of 30-50cm. The image was then processed by a manual cropping inorder to remove light shadows on cervical or lateral borders. The results hold up the favour for digital camera in shade reproduction.

Mehta R (2014)gave an updated review about color selection in dentistry. Older method of shade selection ended with some limitations due to opalescence, translucency, fatigue. Hence newer methods came to exist in modern dentistry for accurate and perfect reproduction of ceramic match. They includes RGB devices, digital camera, spectrophotometer, colorimeter and stump shade selection.

Jian Wang (2014) did an in vitro study on accurate color reproduction of porcelain by computer color matching system. 21 shade disks of 1mm thickness were prepared from porcelain and polished, measured by using spectrophotometer and matched by using computer. The results shows that computer color matching provides more accurate and effective in reproducing dental ceramic or porcelain.

Sumanth K. Veeraganta (2014) conducted an in vivo study on variation in tooth color value according to age, gender and skin color value. 100 individuals were selected from the Bangalore population with some of exclusion and inclusive criteria's. Single observer is employed in the study who has less than five years of dental experience after getting certified regarding color blindness. The study results about no significant different between gender or skin color where significant

difference among age, younger one evident with lighter values compared to older adults.

DS Moodley (2015) did an in vivo study on colour difference between conventional versus spectrophotometer. Twenty five patients were selected between the age groups of 20 and 25 with complete set of maxillary anterior teeth and vital right upper central incisor. For conventional method Vita Classical and Vita 3D-Master are selected and for spectrophotometric method Spectro Shade was selected. It concluded the study by saying that it would be a best practise to use both methods.

Neelam Pande (2015) conducted an in vitro study on color replication of pressable all-ceramic crowns with stained and unstained extracted maxillary central incisor using spectrophotometer. Low translucency all ceramic restorations can be used in unstained tooth for better results. Medium opacity can be used in both stained and unstained tooth. High opacity can also be used on stained tooth but it not within suitable range.

Vidhya Parameswaran (2016)did an in vitro study on intra oral spectrophotometer and visual methods. Vitapan Classical and Vitapan 3D-Master shade guide are used for visual methods. Ten examiners were employed in the study for matching through conventional method and out of 10, six of them are specialists in prosthodontics and four from conservative dentistry. Results shows that visual methods produce more accurate result when compared to intraoral spectrophotometer.

Aikaterini Tsiliagkou (2016) conducted a study on accuracy and repeatability of color matching devices. Two commercially available shade guides such as Vita Lumin and Vitapan3D-master are selected for this study. Three color matching instruments such as Easyshade, SpectroShade and ShadeVision are used. Based on certain term, conditions and parameter, SpectroShade was considered as the most useful and acceptable device.

Erin Ballard, MS (2017) discussed about expectation and fulfilment of shade selection by using advanced spectrophotometer. Pictorial or descriptive information such as patients (58 male and 45 female), dental students 9 from third and final years), supervising faculty members (general dentist and prosthodontist), level of experience and location of restoration were collected. Based on data collection, reference shade, prescription shade and luted definitive restoration, Spectrophotometer Advance 4.0 shows high amount of satisfaction result

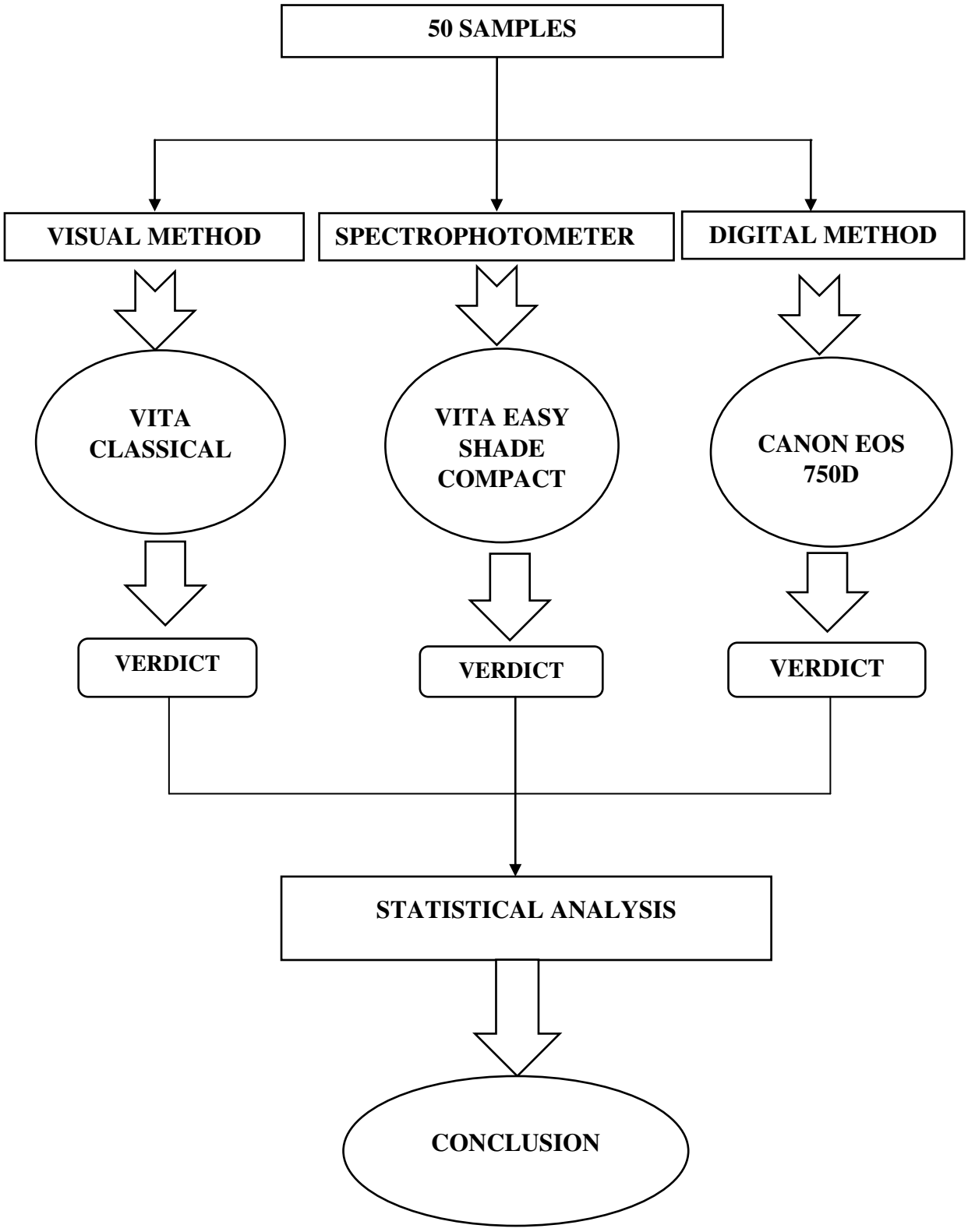
Mohammad Hassan Kalantari (2017) conducted an in vitro study to find out better shade reproduction between conventional and two spectrophotometric systems. Thirteen patients were selected with given exclusive and inclusive criteria's. Preliminary impression was taken and cast poured and mounted in articulator. Tooth preparations were made to receive metal ceramic restoration and master cast poured. The master cast is scanned by using 3D scanner and processed with CAD CAM technology. Three crowns were made for each tooth under visual color selection by Vitapan Classical and Spectrophotometric by VitaEasyshade and Degudent Shade pilot. It concluded that spectrophotometric method provides more reliable and better results than visual methods.

Juzer S.Miyajiwala (2017) conducted an in vivo study for color selection between visual and digital photographic with spectrophotometric methods. Vitapan Classical shade guide is used for conventional method whereas Canon 500D is employed in digital method. 50 outpatients were selected for shade determination with recommended criteria's. This study concluded that digital method can come into authentic shade determination when compared to visual method

MATERIALSUSED FOR THE STUDY

- DIGITAL CAMERA - CANON EOS 750D
- VITA EASY SHADE SPECTROPHOTOMETER (ADVANCE 4.0)
- VITA CLASSICAL SHADE GUIDE (VITAPAN ZAHNFABRIK)
- TRIPOD STAND
- 18% GREY REFLECTANT CARD
- CHEEK RETRACTOR
- BLUE REFLECTANT CARD

METHODOLOGY



Fifty dental students from our dental college of age groups 18-25 with Maxillary right central incisor after undergoing oral prophylaxis were included in this study. Before undergoing shade selection procedure the teeth are dried using cotton. Discolored teeth, restorations, endodontically treated teeth, extrinsic stains, non –vital or fractured teeth, presence of crowns and veneers are excluded and females were asked to remove the lipstick.The study was proceeded after acquiring the necessary approval from the Ethical committee of the Institution and an informed consent from the students.

The spectrophotometer reported the L*, a*, and b* values along with the actual shade whereas the digital photography method reported only the L*, a*, and b* values using Adobe CS software. The shades obtained by the visual method were marked down for further comparisons. The readings obtained by these three different methods were compared and subjected to appropriate statistical analysis.

Before undergoing shade selection procedure, to avoid discrepancy in conventional method of shade selection, Munsell color test and pseudo chromatic colour plate test was performed for the clinician in an eye hospital , and certificate was obtained from an experienced Opthomalogist. Only after these tests, shade selection procedure was performed. Color is a very subjective assessment which changes from person to person. Literature has clearly stated that the shade of any restoration is influenced by several external factors such as surrounding illumination, environment, the tooth including its textures and layers, the dentist’s personal judgment, and patient factors.

Hence the standardization protocol was followed for evaluating the shade selection

Standardization protocol was followed during the study as follows,

- All the shade matching procedure were performed by the same operator
- The students are made to sit in the same dental chair, directed towards northern facing sunlight
- The entire procedure was done between 12.00pm to 3.00 pm on a bright sunny day

SPECTROPHOTOMETRIC METHOD:

This study was proceeded with 50 students using spectrophotometer i.e., VITA EASY SHADE COMPACTas shown in (fig 1-c)

Spectrophotometer which contains the following components,

- Hand piece
- Base unit
- Calibration block holder
- Power supply

The green power LED light will flash a beam on the base unit once the power supply is connected to the wall electrical output with a suitable adapter, now place the base unit on the flat surface. Insert the Easyshade Advance 4.0 hand piece into the base unit so that the battery charging port fits over the charging pins. The green LED flashes after the instrument has been connected to the power supply. Let the battery of the hand piece charge for a minimum of 5hours before initial use.

It is mandatory to properly sterilize and disinfect the instrument between patient use and to use a new Easy shade infection control shade for each patient to prevent patient cross contamination. The infection control shield also protects the fibre optics in the instrument from destruction. The proper infection control can be done by following steps

- Slide the tip of the hand piece into the shield
- Detach paper backing from the shield
- Tug shield carefully over the hook
- Secure shield on the hook

Locate the tool in the calibration block receptacle so that the probing tip is flush with perpendicular to the calibration block and depresses the calibration block. Starting graduation or calibration may takes a few seconds after the unit is pressed. After successful calibration, the measurement menu is displayed and the unit is ready for use.

The steps followed in selecting the shade using VITA EASYSHADE COMPACT are:

- Have the patient to sit in the chair and lean back his head
- Observe the color gradient of the tooth to be measured precisely
- The probe tip must be placed on the area of the enamel surface that has the underlying dentine.
- The probing tip must be placed perpendicular and flush to the tooth surface
- While holding the probing tip against the tooth, press the measurement button and hold the probe tip against the tooth until two rapid "beeps" can be heard to indicate the completion of the measurement. The color shades and ΔE values are displayed in the instrument as shown in fig 1-a and b
- Maintain a minimum distance of 2mm to the tissue margin
- To receive the extended color information, highlight and select one of the displayed shade results.
- Totally 30 readings can be recorded. Once 30 measurements are completed, they can be shared into computer or mobile phones via bluetooth and the next set of readings are recorded.
- When the battery is almost empty, the Battery icon will flash.

Technical data

1. Spectrophotometer, measurement ranges from 400 -700nm

2. Inductive charging concept with long life AA batteries

3. Output of all tooth shades in the established and standardized shade systems were displayed in the form of VITA classical shade and VITA 3D-MASTER, as well as signs of the VITABLOCS shades and bleached index, in tendering with the American Dental Association.

4. Display of Lab and LCh values

5. Bluetooth interference for wireless communication with the VITA Assist PC software and VITA mobile Assist app.

VISUAL METHOD:

The study was proceeded with the same 50 subjects using visual method of shade selection i.e., VITA CLASSICAL SHADE TAB as shown in (fig 2-a).

Among the subjects, the middle one third of the right maxillary central incisor was selected for evaluation of shade. From the shade tabs, Hue was selected first followed by Chroma. Based upon the corresponding shade tabs, the suitable shade was noted as shown in (fig 2-c)

Inorder to avoid weariness or prostration of the eye, there should be 5s or 7s interval for the investigator to have look at the blue color cardboard sheet as shown in (fig 2-b). To avoid colour confusion make up and lipstick has to be removed. Shade selection should not be continuously performed for more than 3 subjects to avoid error. It was carried out in natural day light 12.00 pm-3.00 pm in clear skies. The subject were viewed at the eye level by placing the shade tab next to the selected tooth. Entire procedure was done with propersterilization, inclusive and exclusive criteria for standardization. Thus visual method of shade selection was done to the subjects.

DIGITAL PHOTOGRAPHY METHOD:

The study was proceeded with the same 50 subjects using digital photography method i.e., CANON EOS 750D as shown in (fig 3-d)Eos 750D features a 24.2 – mega pixel sensor and is specifically designed for casual Photographers who prize excellent image quality, simple and user friendly interface.

The camera was mounted using Harison tripod stand that consist of

- 3 way pan head
- Geared elevator
- Spirit level with carrying case

Using CANON EOS 750D series as shown in (fig 3-a), SLR camera with Harison tripod standas shown in (fig 3-b), the study was conducted. It was connected to laptop (HP laptop) with an image analysing software(Adobe photoshop CS software).

The following procedure was used for image capture for each subject.

1) Patient cheek was drawn back with the help of cheek retractor

2) With the help of lubricant such as petroleum jelly,18% reflectant grey card dipped in 25% alcohol for disinfection was placed on left maxillary central incisor.

3) According to the occlusal level or plane of the patient, the upright arm of the tripod stand was adjusted. The optical axis of the camera was oriented perpendicular to the patient's frontal plane

4) For obtaining correct proportion of the image, the distance between the camera and the patient was maintained upto70 cm.

5) A digital photograph was captured with following camera settings

   Magnification - 1:1 ratio

   Exposure mode - automatic

White balance - automatic

Aperture - automatic

Manual flash mode - off

Fixed white balance –off

Image resolution- high image resolution

File type - JPEG with the same degree of image compression

ISO value - 125 selected

6) The image was processed using Adobe CS software as follows:

- The image was captured and saved as JPEG
- By clicking “CTRL+O” the rescued JPEG was opened in the Adobe photoshop CS6 software
- By clicking “CTRL+L” the levels dialog which consist of histogram chart and three color Dropper tools was opened

- To obtain L*a*b* values of the tooth, middle dropper tool was passed over the grey card of maxillary left central incisor. Red,blue and green vales are thus secured.

- Inorder to change RBG values to L*a*b* values the following steps were initiated.

    1. In the main toolbar, the image was clicked

    2. Mode was selected

    3. Followed by L*a*b* color

Thus the L*a*b* values of grey card are obtained.

- 54, 0 and 0 are known L* a* b* values of the grey card. The L* a* b* values so obtained by the grey card must be modified/regulated to these values. This was completed by clicking on “image” followed by “adjustments” and “hue/saturation.” Similarly, the a* and b* values were found.

- Using the grey card as a reference as shown in (fig 3-c), the photograph was thus systematized.

- The Magnetic Lasso Tool and The “Magic Wand” in the software were used. Magnetic Lasso Tool describes the area on the right central incisor whose shade was to be noted. The “Magic Wand” tool next to it was used to get rid

of the mirroring/reflection on the tooth surface. The right central incisor was now ready for deduction of its L* a* b* values which was done using the depiction in the histogram toward the right-hand side of the screen.

- By using the CIEL* a* b* system formula, L* a* b* values thus obtained by the Adobe software were converted as follows,

• $L^* = L1 \times 100/255$

• $a^* = (a1 - 128) \times 240/255$

• $b^* = (b1 - 128) \times 240/255$

Where L1, a1, and b1 were the L*, a*, b* values obtained using Adobe Photoshop software.

To find out ΔE (difference in shade), L*a* b* values of digital photographic method and L*a* b* values of spectrophotometric method was deliberated by using the formula,

- $\Delta E = [(L1 - L2)^2 + (a1 - a2)^2 + (b1 - b2)^2]1/2$

Wherein, L1, a1, and b1 were the L*, a*, and b* values obtained by the

Spectrophotometric analysis and L2, a2, and b2 were the L*, a*, and b* values determined by the digital photography method.

The digital photographic method gave a data/results in terms ofthe L*, a*, and b * values. These L*, a*, and b * values cannot be directly converted into a standard tooth shade (e.g., B1,A1, A2,B2 etc.). Therefore, score of “agreement” was given with $\Delta E < 2$ and “not agreement” with $\Delta E > 2$, respectively.

SPECTROPHOTOMETRIC METHODS

Fig 1-a VitaEasy Shade Advance 4.0 showing shade color

Fig 1-b VitaEasy Shade Advance 4.0 showing ΔE values

Fig 1-c shade selection done by spectrophotometric method

CONVENTIONAL METHOD

Fig 2- a Vita Classical Shade Guide

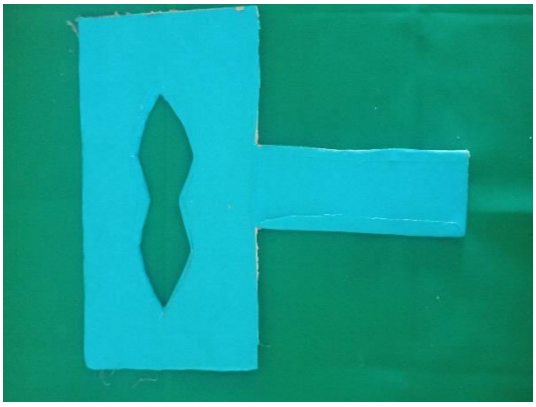


Fig 2-b Bluereflectant cardboard

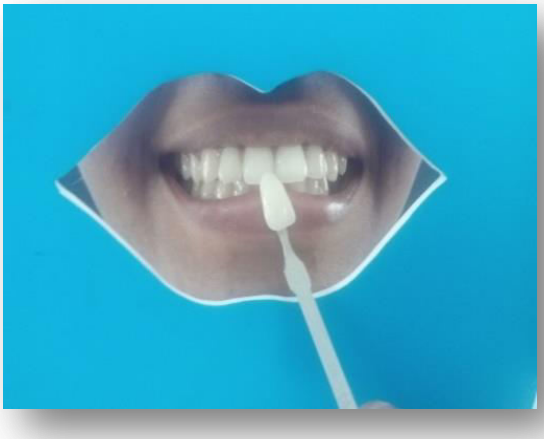


Fig 2-C conventional method of selecting shade

DIGITAL METHOD

Fig 3-a Canon EOS 750D

Fig 3-b Harison tripod stand

Fig 3-c Grey reflectant card in patient mouth

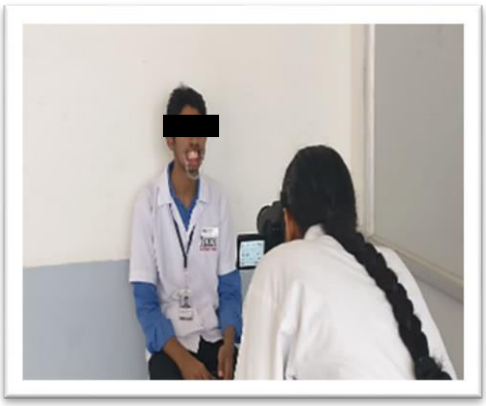


Fig 3-d shade selection by digital photographic method

Table 1: ΔE values and agreement between spectrophotometer and digital methods

S. No.	Spectrophotometric method			Digital method			ΔE values and agreement between spectrophotometer and digital	
	L*	a*	b*	L*	a*	b*	ΔE	Agreement
1	77.5	-2.6	9.4	77.9	-2.4	11	1.38	yes
2	74.3	-1.6	12.5	75	0.8	10	3.69	No
3	78.7	-0.2	15.3	78.1	-0.3	16	0.43	Yes
4	83.4	-1.4	12	84.1	-1.1	11.2	0.61	Yes
5	80.8	-1.6	9.4	80	-2.0	8	1.38	Yes
6	82	-1.2	14	85.1	-1.2	13.9	0.25	Yes
7	73.9	-2.0	11.7	76	-3.0	13.4	4.15	No
8	84.2	-2.4	13	85	-2.1	15.1	2.57	No
9	83.1	-2.2	17.4	84.1	-2.1	15.1	3.15	No
10	80.1	-1.4	14.1	79.7	-0.4	13.9	0.6	Yes
11	83.4	-2.1	16.2	84.4	-3.0	16	0.925	yes
12	83	-2.1	15.3	84.1	-0.84	15.6	1.44	Yes
13	87.4	-2.4	16.1	85.1	-2.0	15.8	2.77	No
14	84.3	-2.1	12.4	84.2	-2.1	12	0.085	Yes
15	70	1.2	11.3	69	1.1	12.0	0.75	Yes
16	69.7	-1.1	11.4	72	-2.4	11	3.57	No
17	69.4	-1.1	11.4	70.4	-2.4	11	1.42	Yes
18	67.6	3	24	67	2.4	26	2.36	No
19	76	1.4	23.3	74	1.5	23	2.30	No
20	78.3	-1.4	12.4	77.7	-1.4	12.2	0.2	Yes
21	82	-2.1	14	83	-2.4	14.6	1.13	Yes
22	84	-2.5	13.1	84.3	-2.0	14	0.575	Yes
23	69.4	-1.4	12.6	69.7	1.9	11	1.45	Yes
24	82	-2.1	12.1	81	2.1	12	0.50	Yes

S. No.	Spectrophotometric method			Digital method			ΔE values and agreement between spectrophotometer and digital	
	L*	a*	b*	L*	a*	b*	ΔE	Agreement
25	78.5	0.7	14	78.4	-0.9	12	2.025	No
26	77.6	-0.5	16.4	76.7	-0.6	16	0.49	Yes
27	74	1.4	32.4	74.3	1.6	32.1	0.145	Yes
28	81.4	-2.4	12.6	80.9	-2.1	12	0.755	Yes
29	78	-1.4	16.1	78.2	1.1	16	0.07	Yes
30	63.7	-2.5	18.4	66.1	-2.4	17.1	3.73	No
31	84.1	-2.1	12.1	83.9	-0.4	12	1.47	Yes
32	77.4	-1.2	11	76.9	-1.2	10.4	0.305	Yes
33	85.2	-1.4	15.1	84.6	-1.3	13	2.39	No
34	79.6	-1.5	15.5	80.1	2.1	15	0.43	Yes
35	82.5	-2.0	13.7	82.4	-0.5	12	2.575	No
36	66.8	-0.4	20.9	67.1	-0.6	20.5	0.73	Yes
37	73.3	-1.3	12.0	73.5	-2.9	12.2	1.68	Yes
38	78.4	-3.0	10.6	80	-2.6	10	1.54	Yes
39	77.4	-1.5	12.4	76.1	-1.8	11.6	1.61	Yes
40	81.0	-1.4	11.6	79.9	-1.4	13	1.58	Yes
41	82.9	-2.4	10.5	82.6	-2.1	11	1.02	Yes
42	86.4	-2.2	17.1	85.9	-2.3	17.4	0.625	Yes
43	80.9	-1.4	15.8	81.0	-1.8	15.3	0.21	Yes
44	84.4	3.4	33.0	83.9	3.1	29.9	5.38	No
45	84.2	3.4	23.1	83.9	3.2	22	1.25	Yes
46	78.9	-1.6	14.3	78.5	-1.3	14	0.49	Yes
47	79.1	-1.2	12.5	77.2	-0.9	12	2.38	No
48	69.2	4.6	30.4	70.4	4.3	30.4	1.17	Yes
49	82.1	-2.0	14.1	80.9	0.9	14	1.33	Yes
50	66.4	-1.7	12.6	67.1	1.4	11.9	0.98	Yes

Table 2. Agreement between spectrophotometer and visual methods

S.No	Spectrometric shade	Visual shade	Agreement
1	A2	A2	Yes
2	A1	B1	No
3	B1	B1	Yes
4	A2	B2	No
5	A2	A2	Yes
6	A2	A1	No
7	B2	B2	Yes
8	B1	B1	Yes
9	A2	A2	Yes
10	B1	B2	No
11	A2	A2	Yes
12	A2	A2	Yes
13	B1	B1	Yes
14	B2	A1	No
15	B2	C4	No
16	A2	B1	No
17	B1	B1	Yes
18	A1	A1	Yes
19	A2	A2	Yes
20	A2	A2	Yes
21	A1	A3	No
22	A2	A2	Yes
23	A2	A2	Yes
24	B1	B1	Yes
25	B2	B1	No
26	A2	A2	Yes

S.No	Spectrometric shade	Visual shade	Agreement
27	B1	B1	Yes
28	A1	A1	Yes
29	A2	A2	Yes
30	A2	A2	Yes
31	A2	A2	Yes
32	B1	B1	Yes
33	A2	A2	Yes
34	A2	A2	Yes
35	B1	B1	Yes
36	B1	B1	Yes
37	B1	A1	No
38	A1	A1	Yes
39	A2	A2	Yes
40	B1	B1	Yes
41	B2	B2	Yes
42	A2	A2	Yes
43	B1	B2	No
44	A2	A3	No
45	A2	A2	Yes
46	A2	A1	No
47	B1	B1	Yes
48	B2	B1	No
49	B1	B1	yes
50	A2	A2	yes

DATA PREPARATION:

The data was compiled in Microsoft excel sheet and transferred to version 20 SPSS software.

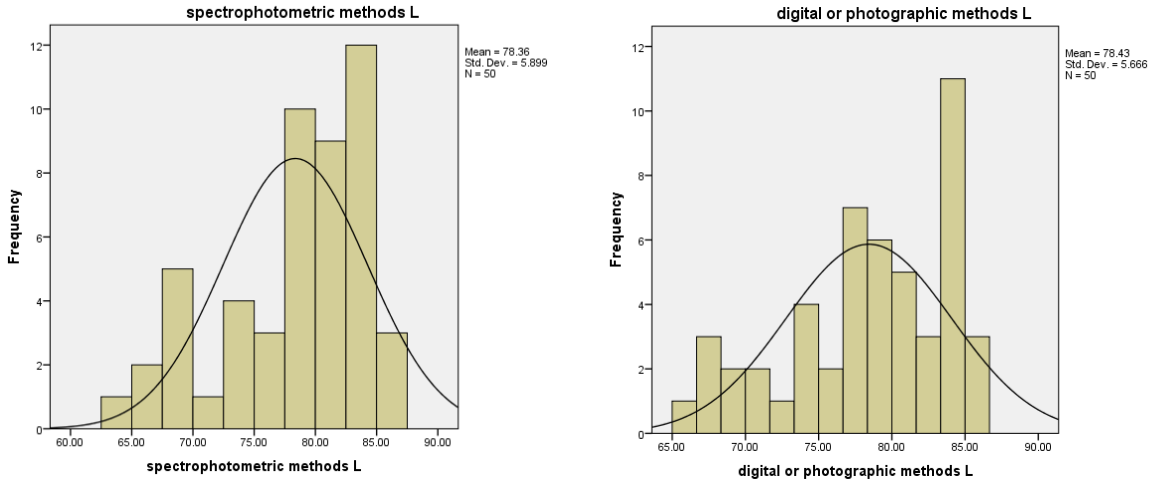
Descriptive statistics and Inferential statistics are been applied.

The data that was obtained is not normally distributed therefore non parametric analysis was used. The following data values are mentioned below:-

Table 3. Tests of Normality

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Spectrophotometric methods L	0.155	50	0.004	0.919	50	0.002
Digital or photographic methods L	0.113	50	0.148	0.914	50	0.001
Spectrophotometric methods a	0.285	50	0	0.78	50	0
Digital or photographic methods a	0.145	50	0.01	0.901	50	0.001

Graph 1: Test of normality between spectrophotometer and digital or photographic method



METHODS GROUP

Group 1 – conventional or visual shade selection

Group 2- spectrophotometric method

Group 3- digital or photographic method

In this study, L, a,b values of tooth shade was selected between spectrophotometric method and digital method. The mean, standard deviation, z values and p values are calculated and tabulated as follows.

Table 4:Comparison between spectrophotometric and digital or photographic methods using wilcoxon signed rank test.

	N	Mean	Std. Deviation	Mini mum	Maxi mum	Z value	p value
spectrophotometric methods L	50	78.3	5.89	63.7	87.4	-0.155	0.877
digital or photographic methods L	50	78.4	5.66	66.1	85.9		
spectrophotometric methods a	50	-0.9	1.74	-3	4.6	-1.166	0.244
digital or photographic methods a	50	-0.6	1.85	-3	4.3		
spectrophotometric methods b	50	15.2	5.38	9.4	33	-2.314	0.021*
digital or photographic methods b	50	14.9	5.28	8	32.1		

P value <0.05*- statistically significant

The difference in shade between digital and spectrophotometric was analysed and the mean and standard deviation for ΔE was tabulated below.

Table 5: Descriptive statistics of ΔE Values.

	N	Mean	Std. Deviation	Median
E values	50	1.49	1.29	1.17

The tooth shade was selected between conventional and spectrophotometric method and analysed by using Chi-Square test and p value for the test is calculated and tabulated as follows

Table 6: Comparison between spectrophotometric method and visual method using Chi-Square test.

		Visual							Chi-Square Value	p value
		a1	**a2**	**a3**	**b1**	**b2**	**c4**	**Total**		
Spectro photo metric methods	**a1**	3	0	1	1	0	0	5	62.261	0.0001**
	a2	2	19	1	1	1	0	24		
	b1	1	0	0	12	2	0	15		
	b2	1	0	0	2	2	1	6		
	Total	7	19	2	16	5	1	50		

P value <0.05*- statistically significant

P value <0.001**- Highly significant

Measurement of agreement between digital and spectrophotometric method was done and kappa value and p value was calculated. Spearmen correlation also calculated and tabulated as follows

Table 7: Descriptive and inferential statistics for measure of agreement.

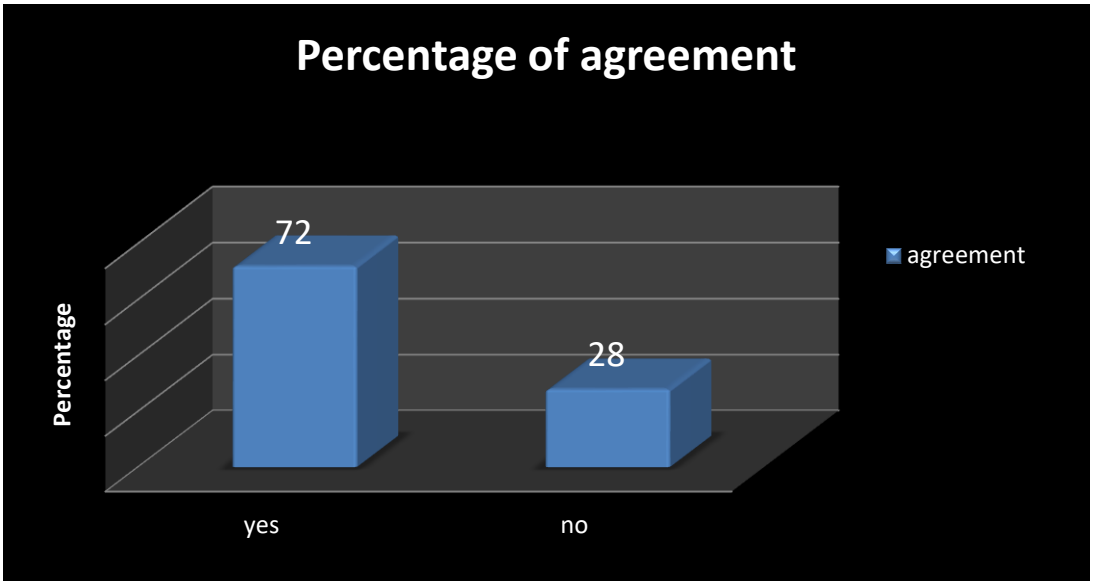
		Frequency	Percent	Measure of agreement		Spearman Correlation	
				Kappa value	P value	r value	P value
Agreement	**Yes**	36	72	0.597	0.001	0.628	0.001
	No	14	28				
	Total	50	100				

Measurement of agreement between visual and spectrophotometric method was done and kappa value and p value was calculated. Spearmen correlation also calculated and tabulated as follows:

Table 8: Descriptive and inferential statistics for measure of agreement.

		Frequency	Percent	Measure of agreement		Spearman Correlation	
				Kappa value	P value	r value	P value
Agreement	**yes**	36	72	0.597	0.001	0.628	0.001
	no	14	28				
	Total	50	100				

Graph 2: Distribution of percentage of agreement between visual and spectrophotometric method and between digital and spectrophotometric method



RESULTS FOR SPECTROPHOTOMETRIC AND DIGITAL METHOD

- In this study, L, a, b values of tooth shade selected between spectrophotometric and digital method was analysed by using **wilcoxon signed rank test.** Among the 50 parameters, 3 mean were taken from both spectrophotometer and photographic method and standard deviation was calculated from those mean.

Table 9: Mean and Standard deviation between spectrophotometer and digital method

MEAN	STANDARD DEVIATION
78.3,78.4	5.89, 5.66
-0.9, -0.6	1.74, 1.85
15.2-14.9	5.38 , 5.28

Table 10: Z and P values of spectrophotometer and digital method

Z VALUES	P VALUES
78.3,78.4	5.89, 5.66
-0.9, -0.6	1.74, 1.85
15.2-14.9	5.38 , 5.28

Z and P shows statistically significant (P value <0.05*- statistically significant)Similarly, the mean and standard deviation for ΔE (the difference in shade between spectrophotometric and digital photographic values are

Mean – 1.49

Standard deviation – 1.29

RESULTS FOR SPECTROPHOTOMETRIC AND CONVENTIONAL METHOD

- Tooth shade selected between spectrophotometric and visual method was analysed by using **Chi-Square test.**

  Chi – square value = 62.216 and the p value = 0.0001 which shows highly significant

  (P value <0.05*- statistically significant

  P value <0.001**- Highly significant)

- On estimating the consensus between the spectrophotometric and digital method, **kappa co efficient** values will be 0.597 and p value will be 0.001 which shows statistically significant with higher proportion. The non-parametric measure of **spearmen rank co relation** will be 0.628 and the p value for that rank is 0.001 which shows statistically significant.

- On estimating the consensus between the spectrophotometric and visual method, **kappa co efficient** values will be 0.597 and p value will be 0.001 which shows statistically significant with higher proportion. The non-parametric measure of **spearmen rank co relation** will be 0.628 and the p value for that rank is 0.001 which shows statistically significant.

Esthetics is often the primary motivating factor for patient seeking dental care. A successful restoration will provide the patient with excellent long-term function. The aim of the dentist is to develop for his patient, a restoration that is best to meet the patient's physiological and biological desires.

The focus of dentistry in the present times is not only the prevention and treatment of diseases but on meeting the demand for better esthetics. Esthetic dentistry is emerging as one of the challenging branches of this field

The importance of esthetics in restorative dentistry has improved among population. Proper shade matching by the dentist is not so easy because it is based upon individual opinion. This becomes tangled by the circumstances of different shade systems. Color evaluation has carved up into 2 categories such as instrumental and visual methods. This study was done to determine the production and performance of correct shade matching method to be practised in a clinical set up[7]

SPECTROPHOTOMETRIC METHOD:

Shade matching of maxillary anterior is one of the tough clinical challenges faced in Dentistry[14]. Prediction and interpretation of tooth color information in ceramic work is a crucial step in color reproduction. Generally spectrophotometer is considered as more authentic when compared to colorimeter in both invivo[11] and invitro[4,5] studies. However spectrophotometer method of shade evaluation is considered as **gold standard**[4]for measuring tooth color and to provide high level of

agreement for the usage of shade selection in dentistry because of the following reasons.

- Precise and reproducible tooth shade determination in seconds –latest measuring technology.

- Objective and reliable measurements –LED technology that is unaffected by ambient conditions.

- Reliable and economical – reliable shade reproduction and reduced shade corrections[24]

- Simple and intuitive – easy to use touch screen and software

- Efficient digital communication – exchanging information about tooth shade and images between dental practice and laboratory [47].

One of the main aim of aesthetic dentistry is to provide functional and natural appearing dental restorations to the patients. To achieve this, spectrophotometers are specially designed to meet the patient demands. Spectrophotometer is an instrument that is basically designed with the following components[1][24]

- Optical radiation

- Detector

- Signal processing system

Spectrophotometer measures and records the energy that are reflected back from the tooth and able to convert that light into signals by signal processing system. It also consist of photodiode detector that stores the light at each wave length. One should abide that natural tooth doesn't have the unique properties of color, due to the enamel translucency, polychromatic nature of the dentin and fluorescence. Hence L, a, b values are co ordinated in shade tab. Manufacturers incorporated this L, a, b values in spectrophotometer for easy identification of color[(1)]. Spectrophotometer is not affected by an ambient light[(14)]The spectrophotometer Vita easy shade advance 4.0 is used in this study. It was developed for fast, precise and reliable shade determination of natural teeth and ceramic restorations in clinical setup. Tooth shade determined by VITA Easy shade are recorded and communicated professionally. The Windows-based PC software combines digital patient photos with all relevant patient tooth information. At the same time it allows for case documentation and provides the basic efficient data exchange between the dental practice and laboratory. During the measurement process, the tooth is illuminated by periphery of spectrophotometer tip directing the light from bulb of halogen onto the tooth surface[(24)]

Data from VITA Easy shade V is wirelessly transmitted to the app via an internal Bluetooth interface and can be combined with the patient photos and can be sent conveniently from a smartphone or tablet[(52)].

Conventional method:

Man's unique ability to distinguish accurate shade difference has evolved through long period of time in natural sunlight. The color temperature of day light

varies from 1,000 kelvin during sunset to over 20,000kelvin in clear blue sky[8]. There are three important things to be considered in shade matching to maintain the standardization as follows[8],

- Light source
- Object
- Detector

Natural sunlight is a mixture of component that falls from the sky along the electromagnetic spectrum of 380nm and 750nm. As the light enters the eye, it is received by the cornea and the lens and the image gets focussed on retina. The pupils gets narrowed during the high illumination and the pupils gets widened during dim or low light[10],[24].

There will be confusion in color vision. It is categorized under 2 conditions

- Genetic color vision confusion and
- Acquired color vision confusion

Genetic color vision confusion is commonly referred as " Color blindness". It affects 8% of males and 2% of females. Loss of color difference signals and cornea type(s) shift in spectral sensitivity are the characteristic features. Reddish green, bluish yellow are the colors that are difficult to discriminate by the people[26].

Acquired color vision confusion are received from certain conditions as follows,

- Diabetes
- Leukaemia
- Alcoholism
- Sickle cell anaemia
- Multiple sclerosis
- Papillary diameter affected by emotion
- Yellowing of cornea (purple and blue color are difficult to distinguish) [26]

Munsell color test and pseudo chromatic color test are performed by investigator as guided by Ophthalmologist[12]. The Munsell color system showing circle of hues at value 5, chroma 6 and the neutral values from 0 to 10. Pseudo chromatic color plates showing colored dots and the number hidden within the dots. Investigator should get informed consent from the students before starting the procedure and also should get necessary acquiesce from the Ethical committee of the institution[41].

Color perception may vary among the individual observer, so a single investigator is employed in the study[11] .The investigator should not continuously perform shade selection for more than 3 subjects. Inorder to avoid weariness or prostration of the eye, there should be 5s or 7s interval for the investigator to have a look at the blue color cardboard sheet as shown in (fig 2-b). To avoid colour

confusion, make up and lipstick has to be removed, from the subject. The subject were viewed at the eye level by placing the shade tab next to the selected tooth. The shade guide shows variations under fluorescence, incandescence or daylight[18]. In order to follow the organised systematization during the entire process, shade selection procedure[40] was carried out in natural day light 12.00 pm-3.00 pm in clear skies of bright sunny day of northern facing sunlight. This is because, for centuries, artist use northern daylight to distinguish color difference [17] and the ideal use of natural light source is mid day to 3.00pm.

Entire procedure was done with proper sterilization[48] , and to avoid any false reading during procedure, restorations, presence of crowns and veneers, endodontically treated teeth, fractured or non-vital teeth were excluded[14]. These procedures were excluded because of enamel translucency, polychromatic nature of dentin, tooth dehydration due to prolonged procedure[18]

Visual shade selection is proceeded after getting certified from the experienced opthamalogist. Using Vita classical shade guide is the conventional method most commonly used by the clinician for decades. It is considered as gold standard in dentistry and so is chosen for the comparison[14] in this study (Vita Zahnfabrik, H.Rauterlimbh and co. KG, Bad Sackingen, Germany). Hue has to be selected first followed by Chroma. Shade tab is arranged alphabetically as follows, A-Orange, B-yellow, C-yellow/ gray, D-orange /gray[24]1-least chromatic highest value,4-most chromatic lowest value.

Digital photographic method:

Digital photography is the third method employed in this study. Between dentist and dental technicians, digital photography could be the major tool in exchanging of information. Recently visual method of shade selection has been replaced by the digital means[65]. This is because it can exactly replicate the color with its high imaging quality[29]

Due to increasing in digital photography and imaging software, the use of digital camera is now omnipresent in color imaging. The primary purpose of using digital photography in dentistry is for recording various aspects of clinical procedures and information in the oral cavity[19]. They may also includes,

- Dental documentation
- Progress and monitoring
- Communication
- Marketing

More than any other health speciality, dentistry has benefited from this trend. It becomes an invaluable asset in daily dental practice. A single picture can explain a hundred words rather than description. Properly maintained records will prevent post-treatment disputes[19].

Unresolved question often remains concerning about which camera-sensor and calibration model obtains the satisfactory color accuracy. The determination of

standard digital (SLR) camera with interchangeable digital sensor would deserve this question[6]

Cameras are classified based upon following criteria's

- Single lens reflection – with interchangeable lens
- Digital camera and intra oral camera – without interchangeable lens
- DSLR –combination of digital with single lens reflection

Canon Eos 750D is used in this study with recommended parameters and settings. DSLR features an intelligent viewfinder which gives a much enhanced shooting experience. As you look through the viewfinder, you can more easily see the viewpoint, any active auto focusing (AF) areas, and also the shooting information is clearly displayed[29].

Camera was connected to HP laptop [Pavillion × 360 with intel core i5 processor] along with imaging analysing software (Adobe Creative Suite CS6 photoshop). This software CS6 released in May 2012, added new creative design tools and provided a redesigned interface with a focus on enhanced performance. Color and adjustments, as well as layers, are among a few things that are featured in this new editor. It is necessary to use high level quality of colored object to obtain possible similar results[29],[62].

18% grey card is used in this study for standardization. A grey card is a middle reference, typically used together with the reflective light meter, as a way to produce consistent image exposure and /or color in film and photography[29]. The red, blue and green values are equal for grey card and hence it considered as a neutral target. Since the grey card had an unquestionable value, the Adobe photoshop CS6 also integrates as grey and thus removing the tint of particular color, usually unwanted, which affects the whole or portion of a photographic image evenly[62].

The vertical arm of the stand and optical axis of the camera were adjusted as guided. The image was captured as a measured distance of 70cm between camera and patient and the proceed image was transferred to Adobe CS photoshop to get L a b values of the image[29]. The L a b values are again converted into L*, a* and b* values by using the formula

- $L^* = L1 \times 100/255$
- $a^* = (a1 - 128) \times 240/255$
- $b^* = (b1 - 128) \times 240/255$

The difference in shade (ΔE) between spectrophotometric and digital photography was calculated by using the formula,

- $\Delta E = [(L1 - L2)^2 + (a1 - a2)^2 + (b1 - b2)^2]1/2$

If ΔE values should be less than or equal to 2, when more than 2 it is considered that human eye is not perceptible to such values[6]

Advances in technology in the areas of computer, the internet and communication has greatly influenced and shaped the modern society. During the past half-decade, dentistry has accomplished the magnification of a new generation of technologies dedicated to the inspection, communication and verification of shade.

This study has been conducted to evaluate the shade difference between visual and digital photographic method with spectrophotometric method. According to literature, human eye cannot predict the exact shade due to presence of external and internal influences like weather, lightening conditions, color blindness etc., Hence digital photographic method or spectrophotometric method are considered to be an alternative for conventional method of shade selection in clinical setup. Though dental spectrophotometer is reliable in selecting the shade, it is not easily available to all the clinicians. Digital camera is a common gadget, used in almost every clinic. Several clinical studies have confirmed that digitalized assisted shade analysis is more accurate and more consistent, compared with human shade assessment i.e., conventional method. To achieve a good digital dental photograph, standardization is very important, i.e. consistent lightening, patient positioning, perspective, depth of field and background.

When compared to spectrophotometric method, digital method of shade selection is economically low and when compared to conventional method, it records in detailed manner in order to perform patient education, documentation of records and treatments etc. The conclusion is that both visual and digital method of shade selection shows high statistical significance of agreement with spectrophotometer, with certain limitations.

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